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High pressure growth and characterization of $SrCrO_3$ single crystal

L. P. Cao* and L. Q. Pan*,†

*Department of Physics, University of Science and Technology Beijing, Beijing 100083, P. R. China

†College of Science and Research Institute for New Energy, China Three Gorges University, Yichang 443002, P. R. China

W. M. Li, X. C. Wang, Q. Q. Liu, Y. W. Long, C. Z. Gu and C. Q. Jin‡

Institute of Physics, Chinese Academy of Science, Beijing 100190, P. R. China

‡Jin@iphy.ac.cn

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Single crystal $SrCrO_3$ was prepared under high pressure and high temperature. Single crystal X-ray diffraction (XRD) result shows a cubic perovskite structure. The magnetic and resistivity measurement results indicate that $SrCrO_3$ is a paramagnetic semiconductor.

Keywords: $SrCrO_3$; single crystal; high pressure.

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1. Introduction

Very rich and interesting properties are exhibited in the transition metal oxide systems due to the strongly correlated electrons and interactions between spin, charge, lattice and orbital, such as high-temperature superconductivity, insulator–metal transition and colossal magnetoresistance.[1–5] Combining with the development of high pressure technology, many new materials with novel physical properties were discovered.

A series of $ACrO_3$ (A = Ca, Sr and Ba) polycrystalline samples were synthesized under high pressure and high temperature in 1960s.[6–8] These samples are transition metal oxides with the unusual high valence Cr^{4+} ion with two electrons in $3d$

‡Corresponding author.

shell. Although many works have been done for these compounds, there are many conflicts in the experiment results. $CaCrO_3$ was reported to be metallic through single crystal resistivity measurement[9] and polycrystalline infrared reflectivity,[10] but insulating behavior was found in polycrystalline resistivity measurement.[10–12] Grain boundaries effect and unstableness of Cr^{4+} on the surface was considered to be the reason leading to an insulating behavior.[10] For $SrCrO_3$, it was reported to be a Pauli paramagnetic metal with a cubic structure by Varma.[7] Recently, it was found that there were two phases with cubic and tetragonal structures coexisting in the $SrCrO_3$ sample, in which the main cubic phase was paramagnetic, but a minor tetragonal phase presented at low temperature accompanied by a magnetic transition.[12–15] However, Zhou *et al.* and Komarek *et al.* respectively reported that $SrCrO_3$ exhibited a semiconductor behavior in resistivity measurement,[4,11,12] and it was considered that the insulating surface layer contributed to the semiconductor character.[12] In this paper, single crystal $SrCrO_3$ has been grown and it shows a paramagnetic semiconductor behavior.

2. Experimental Details

Single crystal $SrCrO_3$ was prepared by using high pressure and high temperature technologies. SrO and CrO_2 were used as starting material. After mixed thoroughly in the glove box filled with argon, the starting material was pressed into pellet and then sealed into gold capsule. The sample was synthesized under 5.5 GPa and 1000°C for 30 min. Single crystal $SrCrO_3$ with the size about 100 μm was obtained.

The single crystal was checked by powder X-ray diffraction (XRD) and single crystal XRD, respectively. Magnetic property was measured by SQUID VSM. Transport property was measured by PPMS using the four probe method. The Pt electrodes on the crystal were deposited by focused ion beam (FIB) system. The surface was etched before deposition to avoid surface pollution.

3. Results and Discussion

XRD pattern is shown in Fig. 1. Only two peaks can be seen and indexed with (002) and (004) of cubic structure with the space group Pm3m, respectively, which indicates that the quality of the single crystal is quite good. Single crystal XRD result gives the same space group Pm3m and the lattice parameter $a = b = c =$ 3.8146 Å.

Figure 2 shows the temperature dependence of magnetic susceptibility curves between 5 K and 300 K with the applied magnetic field 1 T. Zero-field-cooling (ZFC) and field-cooling (FC) curves collapse each other, no magnetic transition was found at low temperature, indicating a paramagnetic behavior. Because the single crystal is too small to exactly measure the mass, the effective magnetic moment cannot been evaluated from the magnetic data.

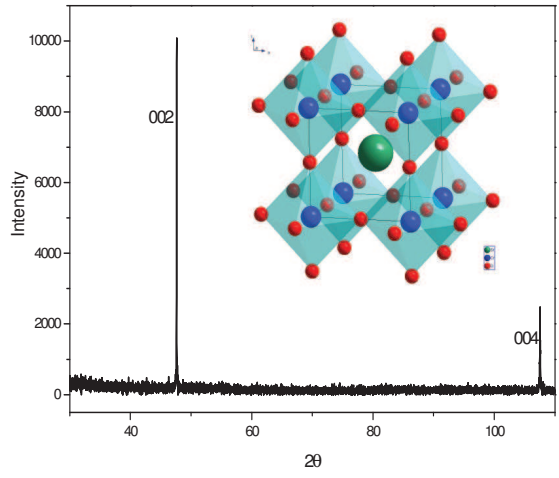

Fig. 1. The XRD pattern of $SrCrO_3$ single crystal. The inset is sketch map of the structure.

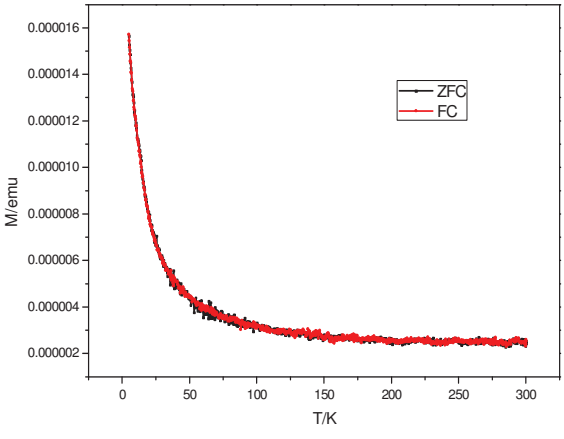

Fig. 2. The magnetic susceptibility curves for the $SrCrO_3$ single crystal with the applied magnetic field 1 T.

The temperature dependence of resistivity curves in both 0 and 5 T field from 2 to 300 K are shown in Fig. 3. Semiconducting behavior with little magnetoresistance is observed. This is the intrinsic property of the sample excluding surface pollution and grain boundaries effect.

4. Summary

$SrCrO_3$ single crystal was obtained by high pressure and high temperature method. The results show that $SrCrO_3$ is a paramagnetic semiconductor with the cubic perovskite structure.

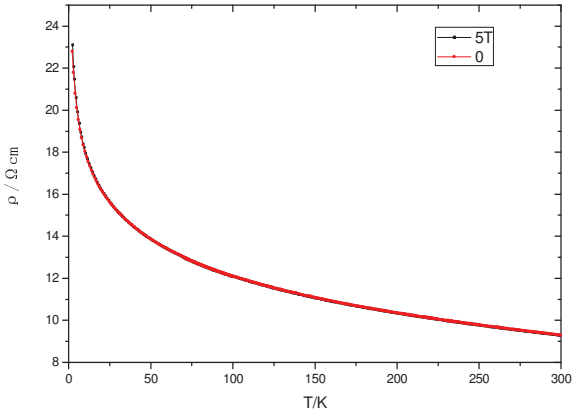

Fig. 3. The temperature dependence of resistivity curves for the $SrCrO_3$ single crystal.

Acknowledgments

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